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ON THE RELATIONSHIP OF THE FISHES OF THE FAMILY SIGANIDÆ.

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The relationship of the family Siganidæ has long been uncertain, though modern authors are unanimous in placing it near the family Acanthuridæ, which it resembles in form of body and in other external features. It was with the hope of finding some skeletal characters that might further indicate its relationship that this investigation was undertaken. The form chosen to represent its family was *Siganus fuscescens* from Japan.

DESCRIPTIVE.

The cranium does not depart very much in shape, nor with few exceptions the elements composing it very much in shape, size, or arrangement, from the percoid cranium with the superior ridges little developed as in the genus *Perca*. The myodome is well developed and opens widely to the exterior at the posterior end of the parasphenoid. The basisphenoid is absent, but at the front of the myodome in the usual place of the descending process from the basisphenoid the interorbital tissue is thickened and separates the eye muscles exactly as the basisphenoid process usually does. The alisphenoids are remote from each other. The exoccipitals meet on the superior surface of the basioccipital; the vagus foramen in the exoccipital is very large. The crest of the superoccipital is moderately developed, but does not reach to the anterior end of that bone. The frontals are large spongy bones, evenly convex transversely, and without ridges or canals. Posteriorly they reach to the epiotics at each side of the supraoccipital which is wedged in between them. To their anterior ends are attached the wide thin nasals, which are joined to each other at the median line and appear like a continuation of the frontals, arching widely over the nasal chambers forming a rounded roof open only outward and downward. The ethmoid is ossified some distance in front of the prefrontals, and is inter-

posed between the vomer and the nasal bones. Posteriorly it is continued backwards as a cartilaginous plate separating the prefrontals and behind them is connected with the tissue of the interorbital septum. The prefrontal is not pierced by the olfactory nerve, but the nerve runs to the nasal chamber through a passage

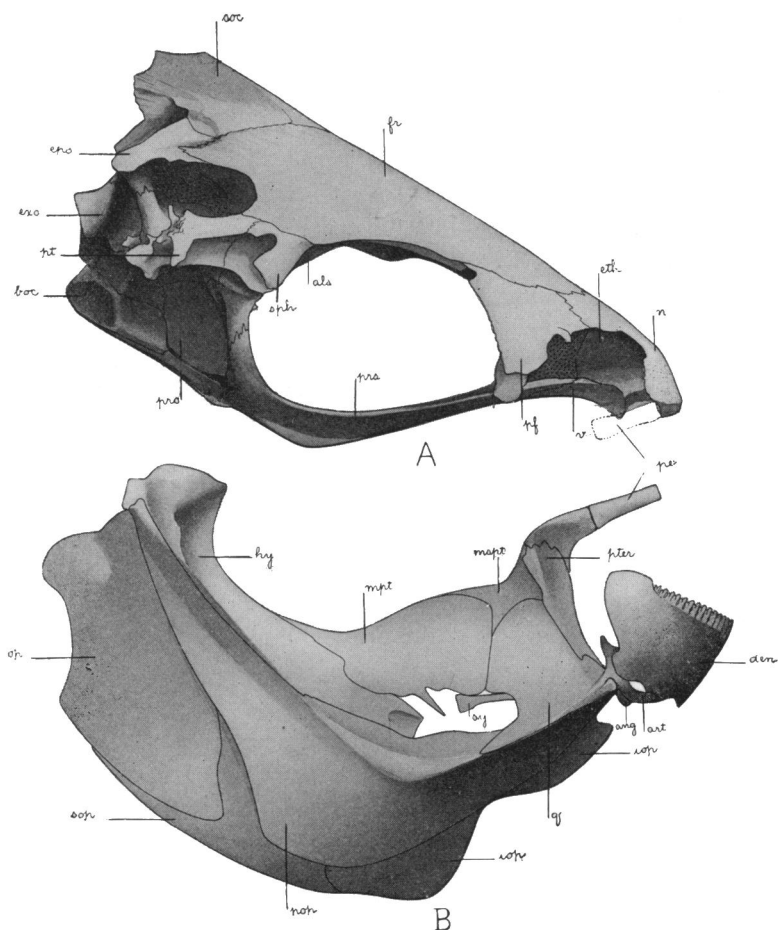


FIG. 1. *Siganus fuscescens*. *A*, lateral view of cranium; *B*, lateral bones of head. *als*, alisphenoid; *ang*, angular; *art*, articular; *boc*, basioccipital; *den*, dentary; *epo*, epiotic; *eth*, ethmoid; *exo*, exoccipital; *fr*, frontal; *hy*, hyomandibular; *iop*, interopercle; *n*, nasal; *mpt*, metapterygoid; *mspt*, mesopterygoid; *op*, opercle; *p*, palatine; *pe*, prepalatine; *prf*, prefrontal; *pop*, preopercle; *pro*, proötic; *prs*, parasphenoid; *pt*, pterotic; *pter*, pterygoid; *q*, quadrate; *soc*, supraoccipital; *sop*, subopercle; *sph*, sphenotic; *sy*, symplectic; *v*, vomer.

between the prefrontal and the ethmoid. The vomer is branched or Y-shaped and toothless. The opisthotic is present in its usual position covering the suture between the exoccipital and the pterotic. The parietal is entirely absent, and the frontal and epiotic bound the supraoccipital.¹ The remaining cranial elements are typical of the majority of the spiny-rayed fishes and are well shown in the accompanying drawings.

The post-temporal is forked and though the lower fork is very short it is continued by a ligament and joined to the opisthotic in the usual way so that the post-temporal stands away from the cranium as it does when the lower fork is long. The superior fork is rather broadly but not firmly joined to the epiotic. A couple of tunneled dermal bones, the supratemporals, are present on each side of the cranium in front of the post-temporal. The hypercoracoid foramen is large and is directly in the center of the bone. The actinosts are moderately long and somewhat constricted in the middle; three of them join the hypercoracoid and one the hypocoracoid. The upper pectoral ray works directly on the edge of the hypercoracoid. The postclavicle is a long, slender, curved ray of bone composed of an upper and a lower element. The other shoulder girdle elements are typically percoid in size, shape, and arrangement.

The lower part of the pelvic girdle extends forward as a long roughened plate just under the skin of the breast. From the upper surface of this plate the girdle is developed vertically upward, and meeting its opposite fellow at the upper edge, which is inclined towards it, incloses a chamber between. Anteriorly a long spine is sent forward from the upper edge of the girdle to between the clavicles. Backward over the base of the ventral fin a triangular spine is developed. The posterior or inner ventral fin spine is attached to the lower surface of this triangular pelvic spine—the anterior or outer ventral fin spine is attached to the base or posterior end of the breast plate. Some space is left between the ventral spines in which the three ventral rays are placed with their bases close together nearer the posterior ventral spine than the anterior.

¹ Several crania of different sizes (the smallest from a specimen 7 cm. in length) were prepared and examined on both the inner and outer surfaces, but no trace of the parietal was found.

The maxillary elements are of rather thin spongy bone rather solidly and immovably attached to each other though not ankylosed. The premaxillary carries a single row of bicuspid teeth (or tricuspid teeth if a scarcely developed third cusp be considered). The usual backward developed spine from the symphysis of the premaxillaries is scarcely developed, and instead of sliding over the vomer and ethmoid between the nasals, it abuts against the shallowly concave front of the ethmoid. A short process from each maxillary fits into a cup at the front of each arm of the vomer, and the movement of the upper jaw is a swinging motion from a hinge similar to that of the mandible rather than the usual sliding motion.

The opercular apparatus is complete and in no way peculiar. The preopercle has an extra long lower limb extending forward from its angle with the upper limb. The hyomandibular is long and with a simple unforked head. It sends no process to the metapterygoid, which occupies a position between the lower end of the hyomandibular and the quadrate. The mesopterygoid is very small but in the usual position between the metapterygoid and palatine and connected with the pterygoid below. The symplectic is small and slender and runs along the inner surface of the quadrate. The pterygoid and palatine are normal in arrangement, the latter attached to the lower edge of the prefrontal, but anterior to the palatine is a prepalatine bone. This is a cylindrical-shaped bone, suturally, but not immovably attached to the front of the palatine and extending anteriorly along the side of the vomer to the upper edge of the maxillary, very much as the anterior process on the palatine in the majority of spiny-rayed fishes does.¹

The mandible is short and resembles the united maxillary bones in shape. The articular is very small and is almost covered from sight by the dentary. A small angular bone is present. The mandibular teeth are in a single row and similar to those on the premaxillary.

The suborbital chain is complete, but no suborbital shelf extends inward around the orbit.

¹ In order to make sure that the possession of this unique prepalatine element was normal three different specimens were examined.

There are two basibranchials ; the hypobranchials of the fourth arch and the pharyngobranchials of the first are absent. There are three pharyngobranchials present on each side, each a thin concavo-convex plate, shaped like a clam shell, and bearing along its lower edge a single row of long, slender, comb-like teeth. A second, less complete row is situated towards the convex center of the plate, though on the first plate the second row is represented by a single tooth. Similar teeth are arranged in four or five "combs" placed obliquely across each slender lower pharyngeal. A third or more of the band of gill filaments of the first arch (and a decreasing portion of it on the succeeding arches), is free from the arch above its angle at the upper end of the ceratobranchial, and rises upward on a cartilaginous base at each side of the cranium in a cavity behind the eye.

The hyoid arch is in no way peculiar in form or arrangement of its elements, except that the paired hypohyals are larger than usual ; a small glossohyal is present.

The vertebræ number as follows : thoracic 10 + caudal 12 + hypural = 23.

The first vertebra has a wing of thin lace-like bone developed outward and downward from the side of its neural arch to which the first epipleural is attached. The parapophyses are scarcely developed, but their small representatives are of about the same size on all of the vertebræ. The ribs are attached to the centra of the vertebræ with the anterior edges of their bases fastened closely against the parapophyses. The epipleurals posterior to the first are attached to the ribs at some distance from the vertebræ. The spine bearing interspinous bones are somewhat wider than the ray bearing ones. They expand laterally at the bases of the spines, making a row of bony plates, which are evident through the skin of the entire fish. The hæmal, neural, interhæmal, and interneural all have a thin lamina of bone developed backwards from their posterior edges. A long, strong process extends forward from the first interhæmal towards the pelvic girdle and forms a sharp abdominal ridge. A sharp spine projects forward from the first interneural at the base of the first dorsal spine and pierces the skin at the nape. The supplementary caudal rays are attached to the backward extending spinous processes of one or two vertebræ anterior to the hypural.

RELATIONSHIPS.

Dr. Gill in the "Standard Natural History" ¹ places the family Siganidæ with the Acanthuridæ under the superfamily Teuthidoidea. The Teuthidoidea he believes to be descended from the Chætodontoid fishes while the plectognathous fishes are descended from the Teuthidoidea.

Dr. Jordan in his "Guide to the Study of Fishes" ² follows the same arrangement but he places the families Acanthuridæ and Siganidæ together with the Chætodontidæ and other related forms in a large group, the Squamipinnes, though he considers the Acanthuridæ and the Siganidæ under different suborders, giving to the latter suborder the name Amphacanthi.

Either of these, with slight changes, is the order in which these fishes are arranged by all modern authors, and as it is apparently the most logical no other arrangement need be here referred to.

Though there is doubtless an alliance between the families Acanthuridæ and Siganidæ the alliance is certainly not close enough to place them in the same superfamily. The Teuthidoidea is defined by the "development of transverse, expanded, buckler-like, subcutaneous plates on the back intervening between the spines, and limiting their erection forward."

The expanded interspinous rays that form the bony bucklers at the base of the spines are developed in this respect only to a slightly greater degree than may be found in many scombroid fishes, and not to so great a degree as in some berycoid fishes.

The fishes of the Acanthuridæ ³ differ from those of the Siganidæ in having the cranium wedge-shaped or tapering to a point at the ethmoid region, the parasphenoid drawn out downward into a wide, thin, sharp plate before the orbital region; the post-orbital part of the cranium shortened; the parietal present; the post-temporal suturally attached to the cranium and forming an integral part of it (this true of *Hepatus* to a greater extent than of

¹ Cassino & Co., Boston, 1885, Vol. III.

² Henry Holt & Co., New York, 1905, Vol. II.

³ *Hepatus bahianus* and *Xesurus punctatus* represent the family Acanthuridæ in this investigation.

Xesurus)¹ the parapophyses developed on all the vertebræ; the postclavical composed of a single piece, though of a similar long, slender shape to that of *Siganus*.

In spite of these differences *Siganus* appears to be more closely related to the family Acanthuridæ than to any other known group. It resembles the fishes of the family Acanthuridæ in having the maxillary and mandibular elements short and resembling each other in shape; the maximillary and premaxillary solidly attached to each other; the spines from the symphysis of the latter short; and the movement of the maxillaries similar to that of the mandible; the teeth flattened, in a single row, and without entire edges; the suborbitals without a shelf below the eye-ball; the gill-filaments extending free above the gill arches in a cavity at each side of the cranium; a spine developed forward from the first interneural spine; the gill openings restricted to the sides.

In the connection of the maxillary elements to the cranium *Siganus* resembles *Balistes* and the other plectognathous fishes, in which the maxillary elements fit against the concave front of the ethmoid region and have a hinge-like movement without any sliding motion forward. In the acanthuroid fishes the ethmoid region is hemispherical in front, and the maxillary elements fit socket-like over it, with very short premaxillary spines above. A movement similar to that in *Siganus* is produced by the maxillary elements turning on the ethmoid ball so that the premaxillary spines glide over the ethmoid somewhat as in the majority of fishes, but there is no sliding motion straight forward.

In most characters, however, the acanthuroid fishes resemble *Balistes* more closely than does *Siganus*. The shape of the cranium is strikingly similar: tapering forward; the parasphenoid extending down in a wide thin plate; the postorbital region shortened; the sphenotic and prefrontal regions curving around the eye; and the postclavicle a long simple ray of bone.

In all of the plectognathous fishes the premaxillary is firmly

¹ The attachment of the post-temporal to the cranium apparently has not the importance sometimes given to it as Dr. Gill has shown in his paper on the affinities of the Ephippiids (Proc. U. S. Nat. Mus., Vol. V., p. 557), or as the present writer has shown in his work on the shoulder girdle of the Hemabbranchiate fishes (Proc. U. S. Nat. Mus., Vol. XXV., p. 619).

anchylosed to the maxillary. In the Acanthuridæ and Siganidæ these elements are immovably attached to each other but are held together only by connective tissue.

The peculiar pelvic girdle of *Siganus* has its counterpart in the berycoid fishes, but in this connection probably means nothing. The modification of the girdle is brought about by a development upward of the middle portion so that a chamber is inclosed between the opposing sides.

SUMMARY.

Siganus stands rather widely away from any known form. The possession of the peculiar prepalatine element and the two spines to each ventral preclude a close relationship to any living fishes. Though its relationship to the acanthuroid fishes is not close it apparently was descended from some form near that stock, and the condition of the maxillary elements, particularly their attachment to the cranium, indicate a relationship in the plectognathous direction rather than in the Chætodontoid.

If this be true *Siganus* can only be an off-shoot at one side from some acanthuroid form having the plectognathous articulation of the upper jaw to the cranium. The acanthuroid fishes are in a more direct line with the plectognathous fishes and *Siganus* could not stand between them.

The plectognathous fishes show degeneration from the acanthuroid stock by a series of continuous and ever increasing steps. *Siganus*, on the contrary, shows development in the direction of higher specialization.

The characters of *Siganus* are apparently of sufficient value to entitle it to independent superfamily rank at least, or to a rank coördinate with that of the acanthuroid fishes.